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EFFICIENT FUSION OF MULTIMODAL MEDICAL IMAGES USING NON-SUB SAMPLED CONTOUR LET TRANSFORM

V.Aiswaryalakshmi[1], S.Karthikeyan[2]

Department of Computer Science, Arunai Engineering College, Thiruvannamalai, Tamilnadu, India.

Department of Computer Science, Arunai Engineering College, Thiruvannamalai, Tamilnadu, India.

ABSTRACT- Image fusion for the multimodal images would provide wide applications in the field of medical sciences. The main motivation is to capture the relevant information from the medical image sources and fuse them together to provide a single output which forms as an important system in the medical diagnosis. In this paper a fusion framework is provided for the multimodal medical image fusion using non-subsampled contourlet transform (NSCT). The NSCT uses two kinds of methodology for image fusion, the phase congruency and directive contrast technique. The former is used to fuse the low frequency coefficients of the images whereas the latter is used for the high frequency coefficients of the images. Various multimodal medical images are given as input where the images are decomposed and finally the fused images are constructed by using the inverse NSCT technique. The proposed framework will provide a way to enable much more accurate analysis of the fused images. The applicability of the proposed idea can be carried out with three clinical examples like brain affected with Alzheimer disease, subaccute stroke, brain tumour.

I. INTRODUCTION

Medical imaging has been playing a very important in the field of medical diagnosis since many years. This is a major source for the doctors to diagnose the diseases. Whatsoever the medical imaging has its own kinds of imaging techniques like X-ray, computed tomography (CT), magnetic resonance imaging (MRI). However the characteristics and results of each of these medical imaging techniques are unique. For instance, X-ray and CT can provide images as dense like structure with which the physiological changes could not be detected whereas in MRI images even the soft pathological tissues can be visualized better. As a result the anatomical and functional medical images are needed to be combined for better visualization and for accurate diagnosis.

To serve this purpose the multimodal medical image fusion is an effective way to provide solution to generate information from medical image fusion. This fusion technique not only provides accurate diagnosis and analysis but also helps in reducing the storage cost by reducing storage to a single fused image.

Various image fusion techniques have been discovered and implemented so far. These techniques are generally categorized three stages. They include pixel level, feature level and decision level fusion. Most medical image fusion goes with the pixel level fusion. Pixel level fusion has the advantages of retaining the original measured quantities and found to be computationally efficient. And so this paper can also be considered with the pixel level fusion.

II. BACKGROUND AND RELATED WORK

Traditional image fusion algorithms serve the purpose of fusing the images from multimodality images and produce a single fused image as output. Some of the images fusions techniques are based on discrete wavelet transform (DWT), Wavelet packet transform (WPT), Ripplet transform, Framelet transform, Curvelet transform and so on

Many comparative studies shows the Wavelet decompositions servers good for discontinuities that are isolated in an image but it is not so much good at edge and texture regions. And further it captures limited information from the images such as the horizontal, vertical and diagonal directions only. To overcome these issues the multiscale decomposition technique known as the NSCT decomposition technique can be adopted in fusion of the medical images which is very important for the medical experts to diagnose the health issues of a person. For example the wavelet transforms perform the image compression and denoising efficiently. Same way each and every technique has its own unique features and functionality which are very important in image processing.

Same way the non-subsampled contourlet transform has the property of providing a multiscale, multidirectional, shift invariant image decomposition that can be efficiently implemented by means of the fusion techniques or algorithms.

III. THE NON-SUBSAMPLED CONTOURLET TRANSFORMS

A.NON-SUBSAMPLEDPYRAMID STRUCTURE (NSP)

The multiscale property of the nonsubsampled contourlet transform is preserved by this NSP. The contourlet transform is constructed by combining laplacian pyramid and the directional filter banks.

The pyramidal filter bank structure plays important roles in the compression applications as a result of production of very little redundancy by the pyramidal filter bank with the contourlet transform.

Two channel non-subsampled 2D filter banks can be used to achieve the multiscale property in the NSCT domain.

B.NON-SUBSAMPLED DIRECTIONAL FILTER BANK (NSDFB)

The downsamplers and upsamplers are eliminated from the directional filter bank to contain the nonsubsampled directional filter bank. The nonsubsampled directional filter bank produces a tree structured filter bank.

C. COMBINATION OF NSP AND NSDFB

The NSCT is actually the combination of both non-subsampled pyramid and non-subsampled directional filter bank. The NSCT must be constructed very carefully in such a way it does not affect the upper stages of the pyramid because applying directional response at lower and higher frequencies may cause aliasing due to the tree structured format of the NSDFB.

D. DIRECTIVE CONTRAST

The directive contrast is one of the fusion rules to fuse the high frequency coefficients of the input images. A way to select high frequency coefficients is to know the better interpretation of the image.

The high frequency coefficient of an image generally denoted to the bright and sharp regions of the image which includes the region boundaries, edges, lines and so on.

The sum- modified- laplacian (SML) is integrated with the directive contrast to identify the better interpretation of the image as well as to produce accurate results.

E. PHASE CONGRUENCY

The phase congruency is the fusion rule used here to fuse the low frequency coefficients of the input images, which produces the contrast and brightness invariant representation of the low frequency coefficients of the image.

Thus it provides the benefit of selecting and combining the contrast and brightness invariant of the low frequency coefficients of the image. It provides the luminance and contrast invariant feature extraction in the low frequency coefficients of the image.

The phase congruency is mainly used in the feature perception of the image based on local energy model, which postulates the important features of the image at points of pixels.

IV. THE FUSION FRAMEWOK

A. FUSION OF LOW FREQUENCY SUB IMAGES

The approximation component of the source images are identified by the low frequency components of the image. For many years the conventional averaging method is been used which would fuse the low frequency coefficients.But the averaging method will not be able to fuse the low frequency coefficients so effectively to a high quality medical image.

To provide high quality low frequency fusion the phase congruency rule is adopted which will provide the best feature perception and good quality low frequency coefficients.Initially the features of the low frequency sub images are extracted by the phase congruency extractor. Then the low frequency coefficients are fused for feature perception by local energy model.

B. FUSION OF HIGH FREQUENCY SUB IMAGES

The high frequency coefficient of an image usually includes the detailed components of the source image. It is to be noted that the noise also includes in the high frequency coefficients of an image which may eventually lead to increase the distortion of the image.

To avoid these kinds of problems the directive contrast based fusion rule is proposed for fusing the high frequency coefficients of the input sub images.

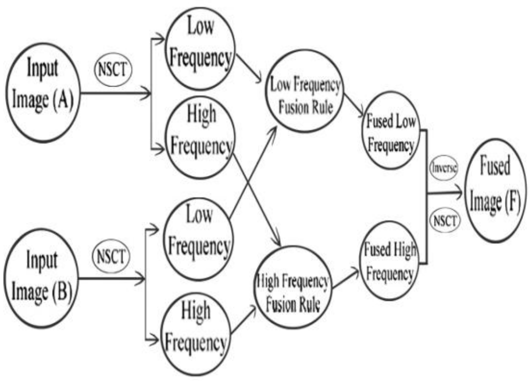
Initially the directive contrast in NSCT is applied to each and every point and orientation in the input sub images to produce the high frequency coefficients of the image. Then the fusion of high frequency coefficients is performed.

C. TREATING LOW AND HIGH FREQUENCY SUB IMAGES

After the completion of low and high frequency coefficients fusion using the NSCT based phase congruency and directive contrast respectively the l-level inverse NSCT is applied on the fused low frequency image and the fused high frequency image to obtain the final fused image.

V. SYSTEM DESIGN

A. SYSTEM ARCHITECTURE



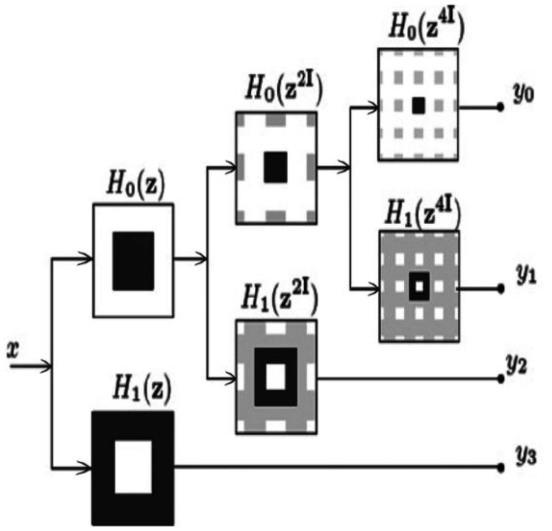
(a)Fusion of CT and MRI image using NSCT based transform

The input images taken are the multimodal medical images such as CT, MRI, PET scans. These images are obtained as input initially. The input images are decomposed by means of non-subsampled pyramid decomposition which is of three stages represented in (b).

Then the non-subsampled directional filter bank decomposition represented in (c) is used to decompose the images. Then the images are subjected to fusion of low and high frequency coefficients by means of the phase congruency and directive contrast respectively.

Low frequency fusion rule, phase congruency is used to obtain the fused low frequency image. High frequency fusion rule, directive contrast is used to fuse the high frequency coefficients of the image.

The fused low frequency image and the fused high frequency images are then separately subjected to inverse NSCT transform to obtain the final fused image.

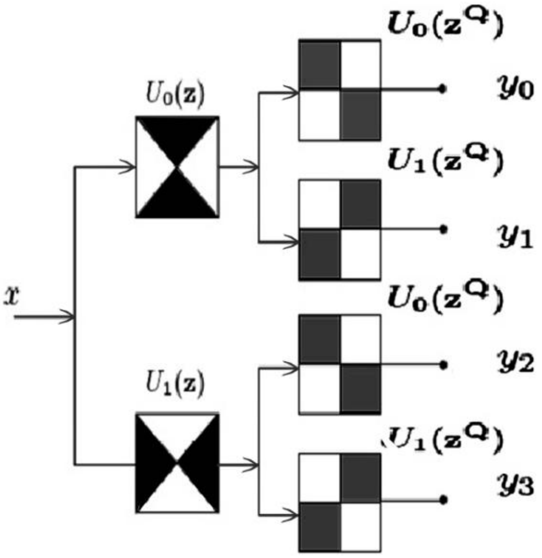


(b)Three stage pyramid decomposition

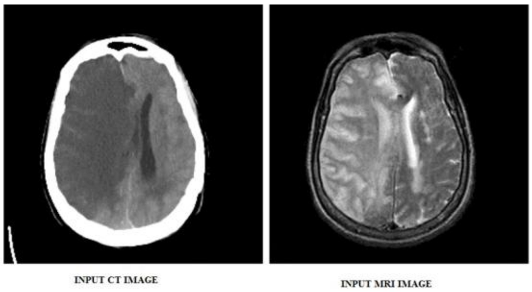
The three stage pyramid decomposition is used to decompose the images. It ensures the Multiscale property of the images by using the two channel non-subsampled filter bank with which one low frequency image and one high frequency image are produces at the end of each non-subsampled pyramid (NSP) decomposition level.

The NSP results in decomposing k+1 images in which one is low frequency image and k- high frequency image where k denotes the number of decomposition levels. The non-subsampled directional filter bank (NSDFB) is also a component of the NSCT which is used to decompose the sub images represented in (c). Directional fan filter banks are combined to construct the non-subsampled directional filter bank.

The non-subsampled pyramid preserves the Multiscale property likewise the non-subsampled directional filter bank provides and preserves the multidirectional property in the images and also directional detail information can be obtained precisely.



(c) Four channel non-subsampled directional filter bank

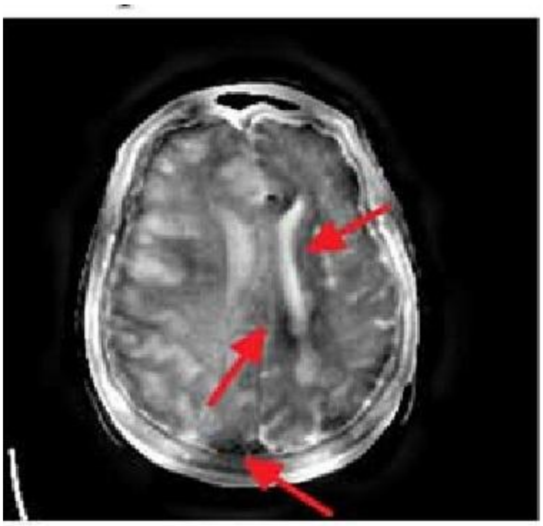


(d) Input CT and MRI image

The CT image produces the dense structure of the image very clearly and the MRI image produces the minute soft pathological tissues clearly.

The fusion of these two input image is carried out as,

Reading the CT and MRI image using the NSCT and then decomposing the image by the filter banks and pyramid decomposition, then fusing the low and high frequency image by phase congruency and directive contrast respectively and finally obtaining the fused image as in (e) by applying inverse NSCT transform.



(e) The fused CT and MRI image.

The NSCT performs better than other conventional fusion algorithms due to the tool which provides Multiscale geometric analysis of the images. Also the property of multidirectional, shift invariance and frequency point localization are provided and preserved from the source image also.

The directional vector is used in this technique which is highly used to maintain the clarity factor of the images. This technique performs better in both multifocus images and the medical images.

This kind of effective fusion method in NSCT involves,

Gabor filter bank

The Gabor filter bank is used in the NSCT domain for edge detection of the images. The Gabor filter is a linear filter where its frequency and representation of the orientation are alike human visual system. This filter is very particular about the texture region of the images and preserves them.

Gradient measurement

The gradient measurement is needed to measure the slopes and tangents in the plots of the graphical representation of the 2D image where the medical images are very sensitive to even minor changes in the fused image which would result in abnormal diagnosis. So the gradient measurement is done under the NSCT domain.

Pixel level fusion

The pixel level fusion is carried out to fuse the image in this system. There are other fusions levels like decision level fusion, feature level fusion but then the medical image fusion are mostly carried out in pixel level fusion due to it advantageous feature of preserving the original measured quantities and it is computationally efficient. The very well known pixel level fusion includes principle component analysis, independent component analysis, contrast pyramid, gradient pyramid.

Highlight features of the proposed system

The most advantageous feature of this system would contribute to reduce the storage cost and space of the images. Also reduces the time of the physician is in diagnosing the problems from the scans simultaneously. Fused scanned images would provide more time to be saved instead of viewing two or more medical images simultaneously. Fused image would provide more information at the curves and edges as well as preserves the important information of the original source images.

One of the NSCT methods uses the directional vectors which can also be used for defining the clarity factor and also efficient in collecting pixels from both blur and clear regions. Other NSCT based methods provides the advantages of performing better than other multi resolution algorithms. The main reason for the better performance of this system than the other conventional algorithm is due to the implementation of the powerful fusion rules for fusing low and high frequency coefficients which protects the prominent texture and regions with more care.

V. CONCLUSION

Thus the clinical examples of combinations CT/MRI, MRI/PET, SPECT/MRI images can be used to test the ability of the system to be the best compared to the conventional systems. This deserves to be the best analyzing system by means of using the powerful fusion rules for fusing the low frequency coefficients together and the high frequency coefficients together from the various source input images. Further to provide the practical applicability of the system this can be applied to clinical examples like brain affected with Alzheimer's disease, stroke and brain tumors.

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